Artificial Pelvis for Assistive Walking

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Fig. 1. The seven-link structure that imitates human walking gaits where \( l_{hi} \) and \( l_{ri} \) represent two pendula from the device and located on both sides of the waist.

**I. INTRODUCTION**

Studies have indicated critical effects that the pelvis exhibits to human walking gaits, including affecting the scope of the stride as well as the moving speed. It also assists the movement of the center of mass for the purpose of reserving energy during walking [1], [2]. Therefore, providing structural support through an external device to a weakened pelvis will help reinstate the normal walking gait. To be able to precisely describe the dynamics of the pelvis during movements in a lower-body structure poses a challenging issue. This paper proposes a wearable mechanism to mimic the pelvis action.

**II. PROPOSED WEARABLE SYSTEM**

To construct an assistive device that improves the pelvic functionalities, a wearable device consisted of two inverted pendula is proposed. With the help of a waist belt, the assembly can be worn keeping pendula at the lateral sides of the person. To mathematically model, a seven link stick figure is assumed (Fig. 1) that represents the torso, both left and right pendula, and two legs of two links each. The leg link lengths and masses are assumed to be that of a 79.2 kg heavy human with a body length of 1.785 m, and are calculated from Anthropometry tables available in the standard biomechanics literature. Each pendulum is assumed to be 25% as heavy as the torso and the length is taken to be 50% of the torso length.

**A. Effects of Pelvis Movements**

To investigate the effect of pelvis movements on the human stability, a simulation is developed where the following actions are being taken:

- The two pendula swing back and forth about the torso within a range of ±90°.
- The legs and the torso are tasked to keep a constant angle.

The controller design consists of a Coriolis and gravity force compensation along with a PD controller for constant angular positions for the legs and torso, and a time-varying angle for both pendula. In Fig. 2, resulting variation in the center of mass (COM) is seen. Currently, the variation of COM along the x-axis is merely 10 cm. It is significant compared to the center of pressure sway typically recorded in a biomechanics study in a standing posture [3]. Therefore, this sway of COM may be useful in generating recovery movements. By tuning the design parameters of the pendula, the variation of COM will be investigated further and a control algorithm will be developed that can exploit this variation especially under the action of disturbance forces.

**REFERENCES**

